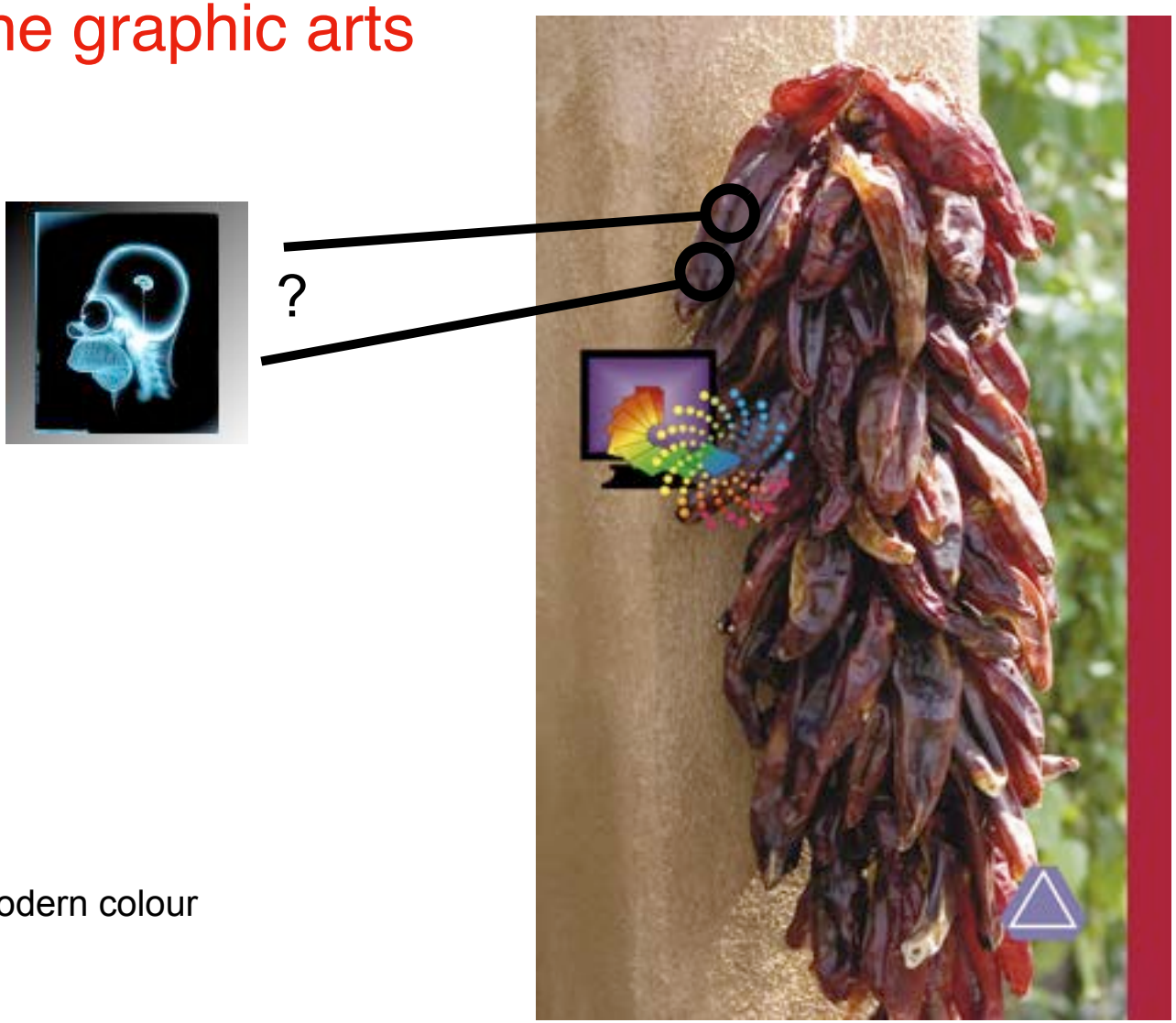
Fogra Roses - Developing a colour difference dataset for the graphic arts



Funded project: Evaluating modern colour difference formulae.
IGF-Nr.: 14893 N

Andreas Kraushaar | kraushaar@fogra.org

Agenda

1. Graphic arts image assessment
2. Modern Colour difference formulae
3. Experiment: “Fogra-Roses”
4. Summary & Out view

1. Image appraisal in the graphic arts

Image appraisal:

... visual comparison of an original with a reproduction aiming for close match ….

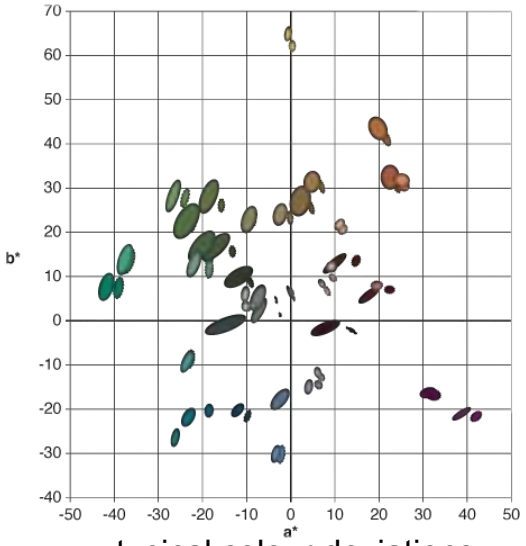
- Contrast [local and global]
- Detail sharpness [Resolution]
- Colour differences
- “Tone”
- Uniformity

→ only few objective assessments

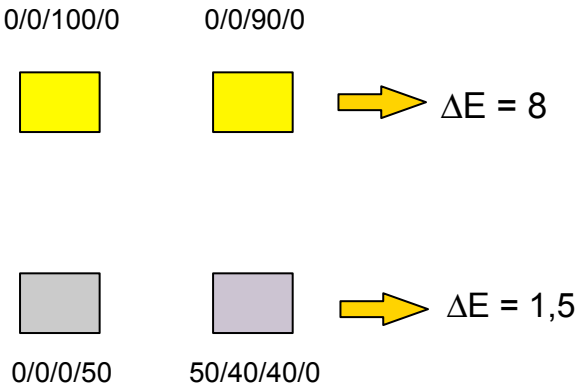
Source: bvdm

1. Current Problems

- Established tolerances are based on pass/fail (technical realizability) and provides little visual meaning
- The established meanings of CIELAB 1976 colour differences are not very practical (see Table)
- Established CIELAB 1976 does overrate yellow and underestimate grey areas ...



typical colour deviations



ΔE^*_{ab}	*Perceived difference*
< 1	normally not visible
1 and 2	small differences
2 and 3,5	average differences
3,5 and 5	well detectable differences
> 6	strong colour difference

Schlaepfer, 2003

2. Modern colour differences

„It is hard to imagine that colour can be communicated by easy figures or functions …"

U. Schultz, Diss., „Umfeld und Farbabstandsurteil“, 1981, S.125

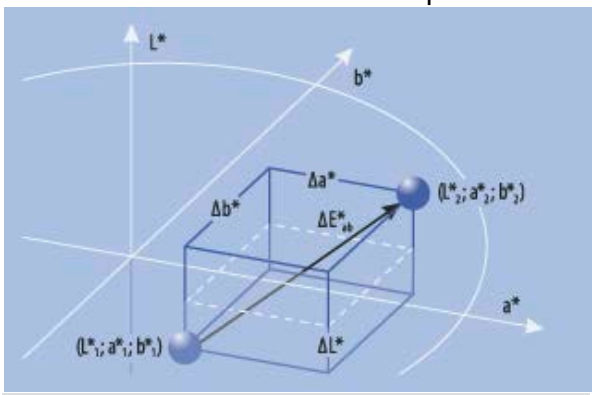
„Unfortunately some physicists sinned when doing psychophysical studies. On the other side many psychologists struggled to honour clear physical and psychophysical experimental designs …"

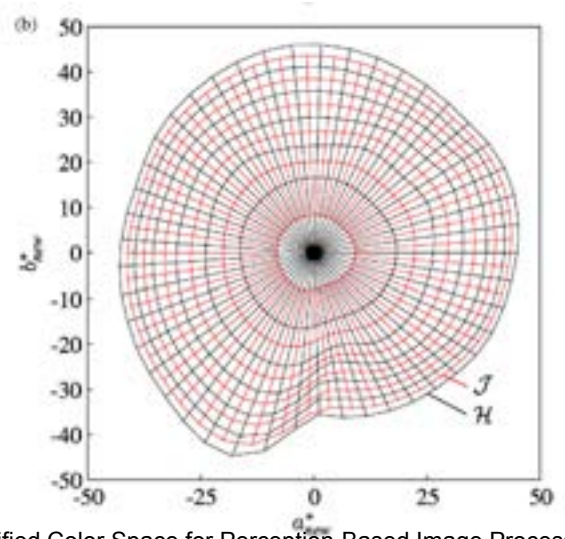
M. Richter, „ Zeitschrift für Sinnesphysiologie“, 1935, S.68

2. Modern colour difference formulae ...

- Euclidian differences in established spaces (CIELAB 1976)
- Weighting of components (CMC, CIEDE94, CIEDE2000, Lübbe formulae etc.)
- Transformation into a new space (DIN99, CIECAM02)
  - "Euclidisation" of a colour space (Urban 2007 & 2012)

Bildquelle: bvdm





Urban, 2012,
Toward a Unified Color Space for Perception-Based Image Processing

2. - Requirements for practical formula

- Simple usage and easy to communicate
- Visualization and interpretation of colour components (hue, lightness and chroma)
- Symmetrical implementation (not standard and trial)
- Perceptual uniform
- Easy to retrofit in established environments and devices

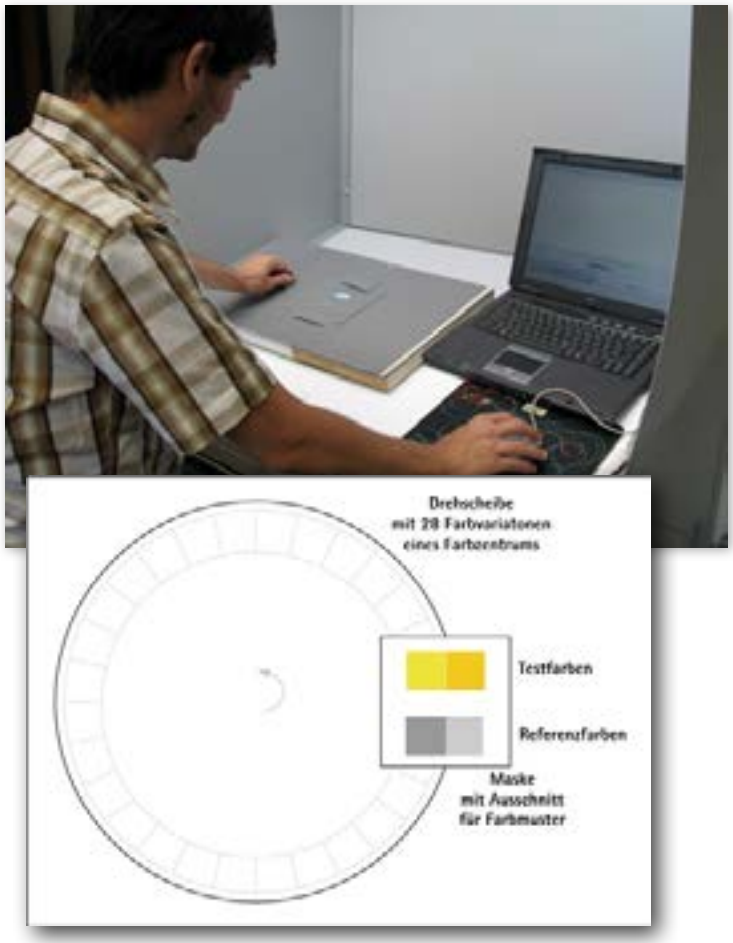
→ What is the most appropriate formulae (for the graphic arts) ?

→ Shootout!

3. - Experiment: Fogra-Roses

Motivation: To established a colour difference dataset that reflects graphic arts needs.

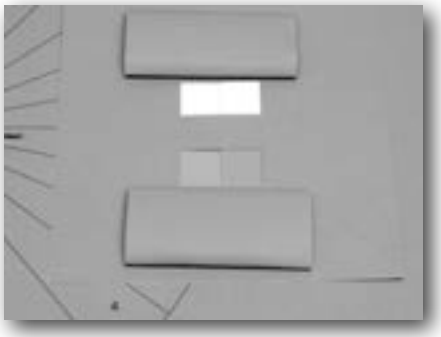
	CIE-Reference conditions	*Graphic Arts (Fogra-Experiment)*
Light source	D65 (Simulation)	D50 (Simulation)
Illumination level	1000 lx	2000 lx (luminance of paper ≈ 400 cd/m^2)
Observer	normal sighted	normal sighted + experienced
Surround	average grey (CIEL*≈50) (FOGRA39 CMYK: 0/0/0/64 = CIELAB 50/0/-1)	
Presentation	Surface colour	
Sample size	larger than 4°	ca. 2°
Separation	Side-by.Side	
Typical Colour difference	0 to 5 ΔE^*_{ab}	
Surface structure	uniform, mostly no texture (paints)	uniform, printed samples



3. Colour sample selection

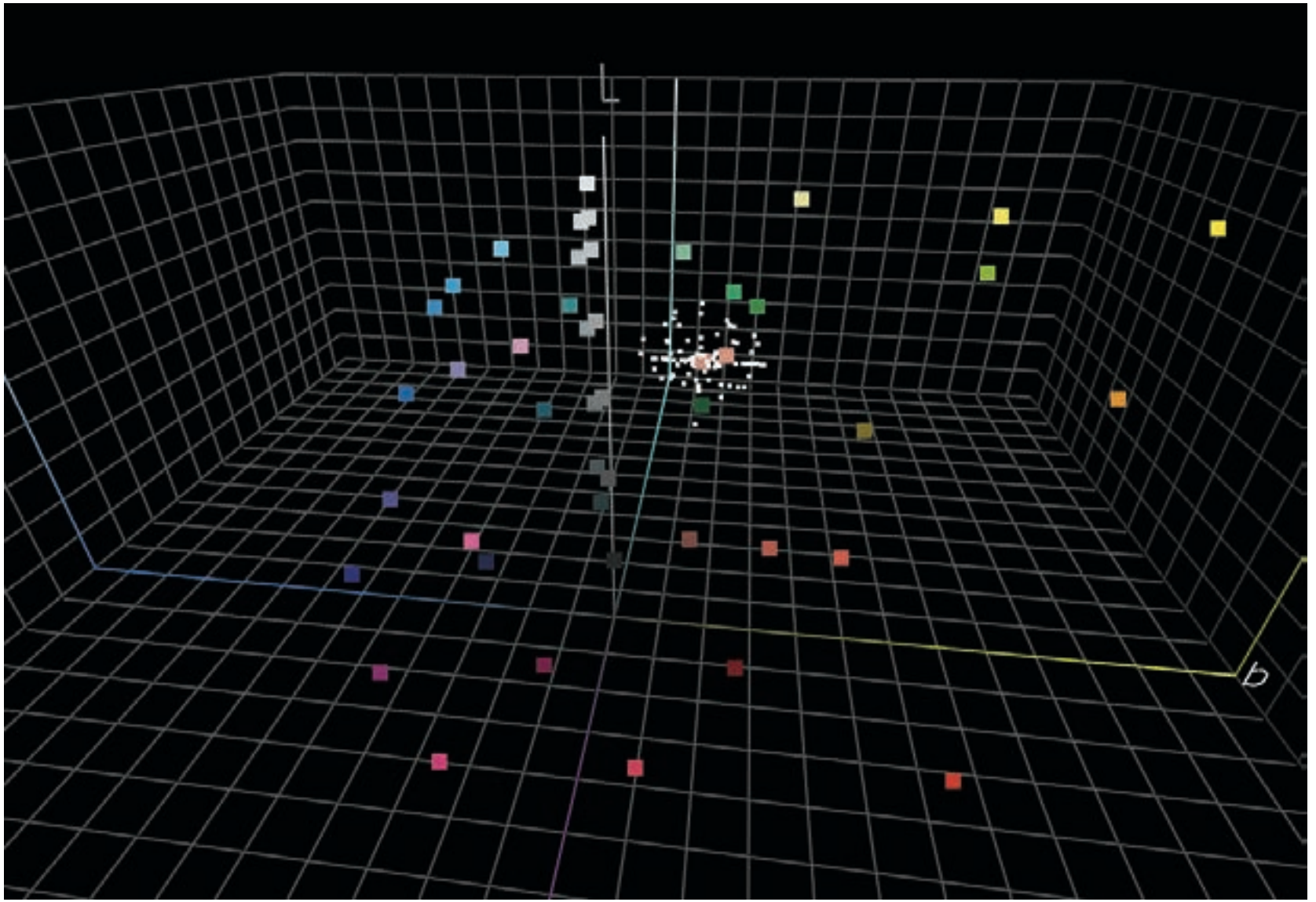
- 46 centres of the Fogra Mediawedge [F39]
- with 28 (+X) colour neighbours
- with 3 Grey reference pairs
- 20 observers

= 77280 matches

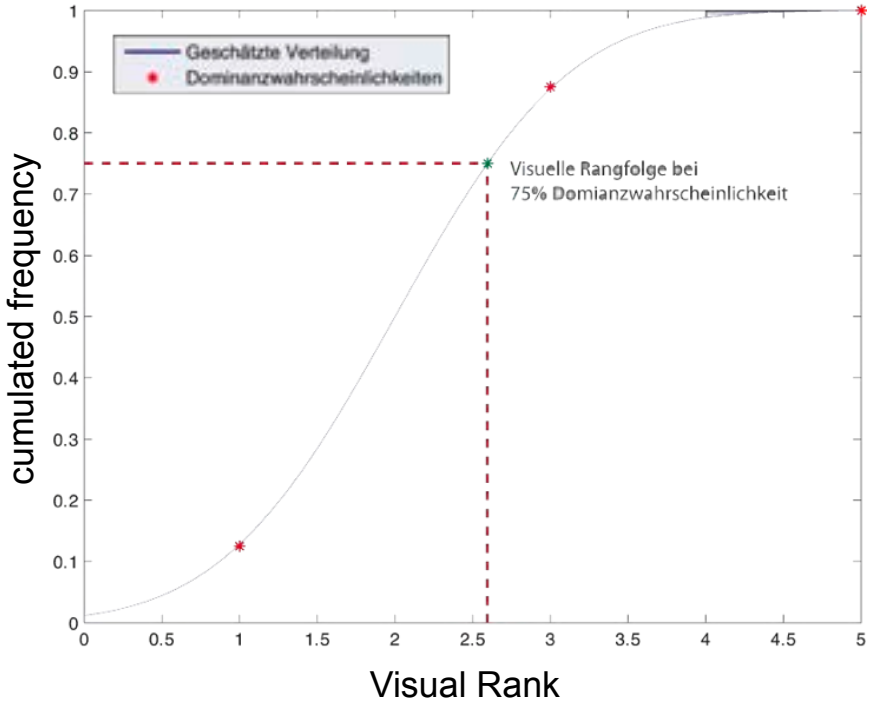


Colour centre: Red

3. Colour centres and it's neighbours



3. Evaluation (Pair comparison constant stimuli)

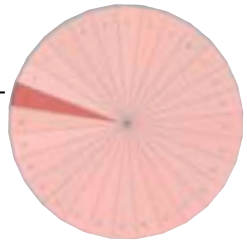


- Consistency check
- Plausibility check
- Quality of data sets [PF/3 und STRESS]

Colour difference data set (1288 pairs)

3. For the skin colours … The winner ist:

Farbzentrum / Parameter	33 („Hautton)“ Testfarbe 1
ΔV_i	2,6
ΔE76	2.3
ΔE94	2,0
ΔE00	1,6
CMC	1,6
Lübbe	2,4
Lübbe korr.	1,7
CIECAM02	2,5
DIN99	1,6
DIN99o	1,9
Anzahl Probanden	8
Anzahl Wiederholungen	0
Messwerte CIELAB1 (Farbzentrum)	71.4, 19.3 17.7
Messwerte CIELAB2	69.5 18.2 16.9

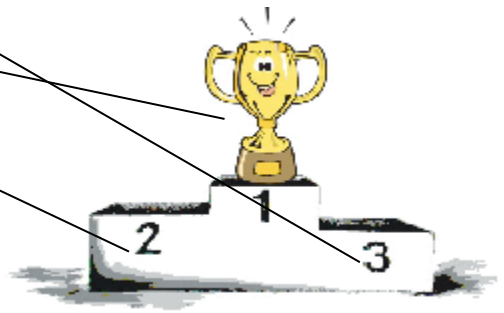


Visual colour difference

Total evaluation:

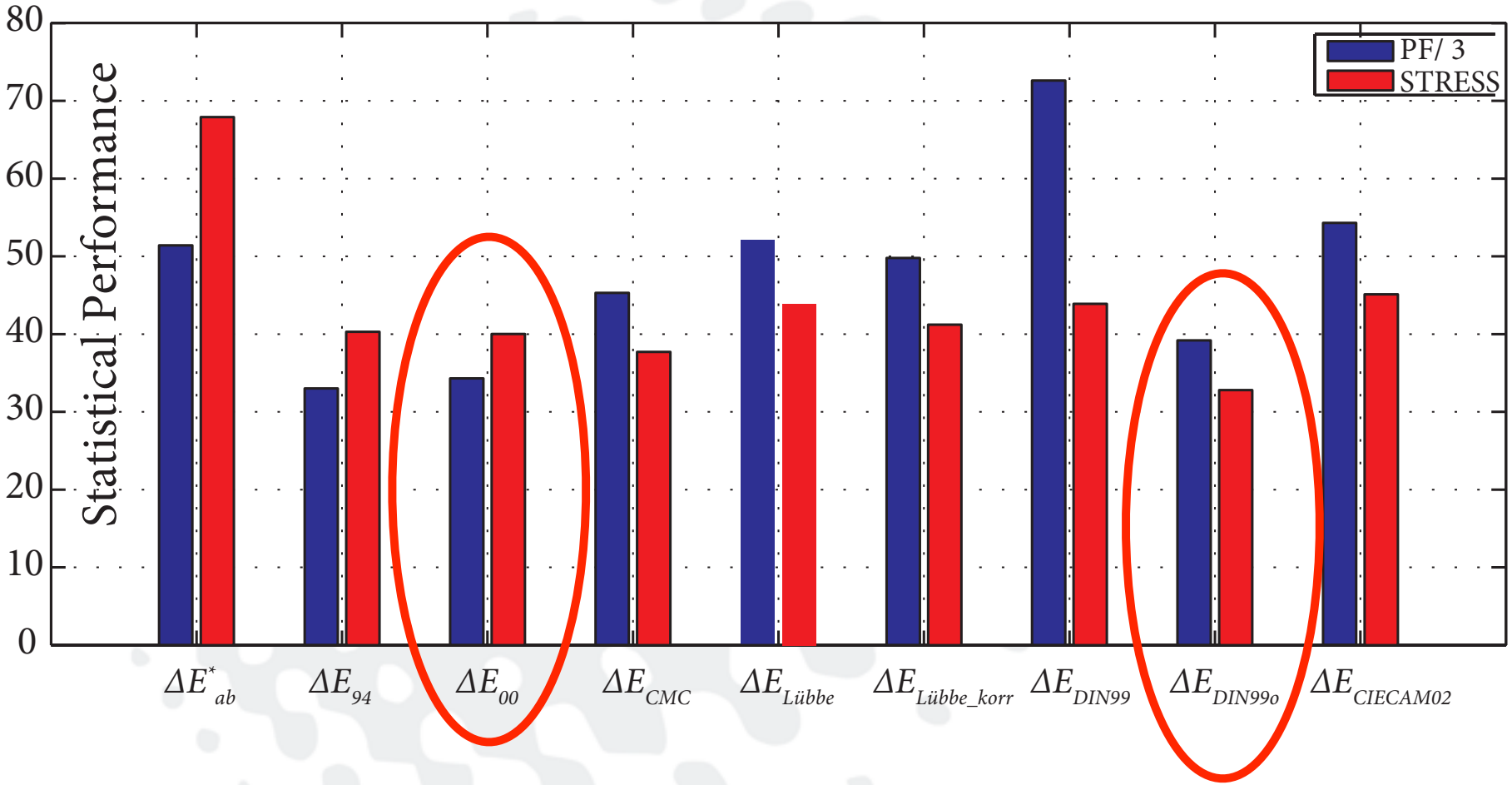
Evaluating variances: $\Delta V_i \sim \Delta E_{xy}$

Performance Factor (PF/3) and STRESS Factor



Entire Dataset can be downloaded from: http://www.fogra.org/en/fogra-research/prepress/research-projects-prepress/colour-difference-metrics/60054-exeriments/fogra-roses2008/a-presentations-prepress-2--2-.html.

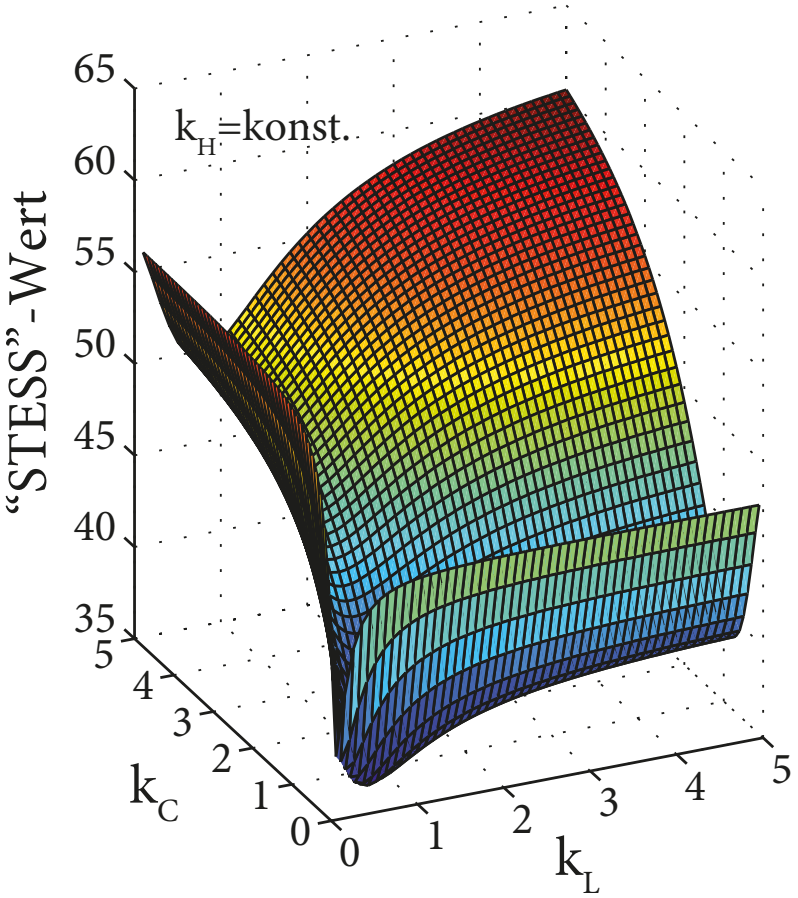
3. Evaluation for all colours

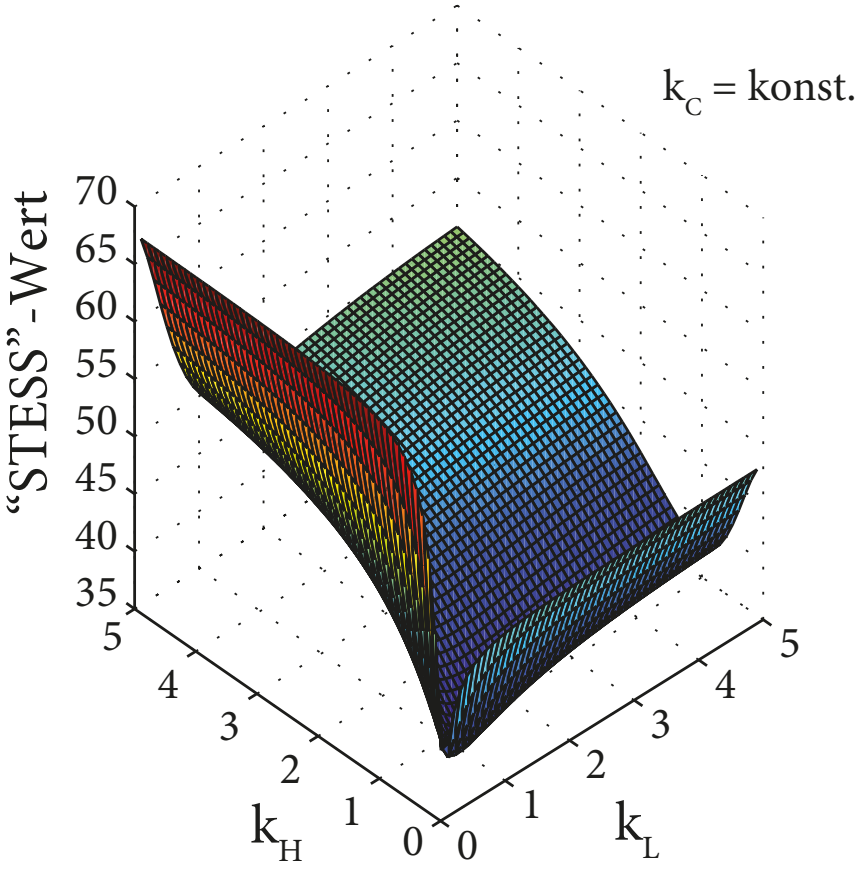


3. Findings

- DIN99o performed best
- CIEDE2000 performs second best
- Practically CIEDE2000 is recommended due to its widespread use and implementation & standardisation
- Fogra is using CIEDE2000 for all new projects and studies (and CIELAB 1976 for comparison and established/legacy evaluations)
- However, the correlation leaves room for optimisation

3. CIEDE2000 Optimization





4. Summary & Out view

- CIEDE2000 is outperforming existing colour differences formulae
- Colour difference evaluation will further develop from patch by patch differences to image differences
- Future studies about media relative colour difference evaluation & common appearance required
- Anyhow, most practical problems relate to wrong usage of instruments, backings, settings and interpretation

⇒ We have to educate the industry!!!